(12) UK Patent Application (19) GB (11) 2 307 342 (13) A

(43) Date of A Publication 21.05.1997

(21) Application No 9623693.0

(22) Date of Filing 14.11.1996

(30) Priority Data
(31) 07295617 (32) 14.11.1995 (33) JP

(51) INT CL[6]
H01L 21/304

(52) UK CL (Edition O)
H1K KLXC K3S9 K3U6A K8VC

(56) Documents Cited
GB 2292254 A EP 0589433 A1 EP 0517594 A1

(58) Field of Search
UK CL (Edition O) B3D DMN, H1K KLXC
INT CL[6] H01L
ON LINE,W.P.I.

(71) Applicant(s)
NEC Corporation

(Incorporated in Japan)

7-1,Shiba 5-Chome, Minato-Ku, Tokyo, Japan

(72) Inventor(s)
Akira Isobe
Tomotake Morita

(74) Agent and/or Address for Service
Mathys & Squire
100 Grays Inn Road, LONDON, WC1X 8AL,
United Kingdom

(54) Apparatus for polishing semiconductor wafers

(57) The polishing apparatus has a retainer ring 11c for retaining a semiconductor wafer WF4 on a polishing pad 14. The outer periphery 11f of the retainer ring 11c is rounded so as to minimize deformation produced in the pad during polishing thereby improving the surface profile of the semiconductor wafer. The retainer ring is formed of hard synthetic resin and is spaced from the hub 11b of the wafer holder 11 by a cushion member 11d. An insert pad 11e is provided between the wafer and the hub. A ring formed of the same material, e.g. quartz, as the wafer may be used. The cushion member may comprise an air bag (Fig 12) in which the air pressure is controllable or it may consist of an adjustable member (Fig 13) for keeping the lower surfaces of the ring and wafer coplaner on the polishing pad.

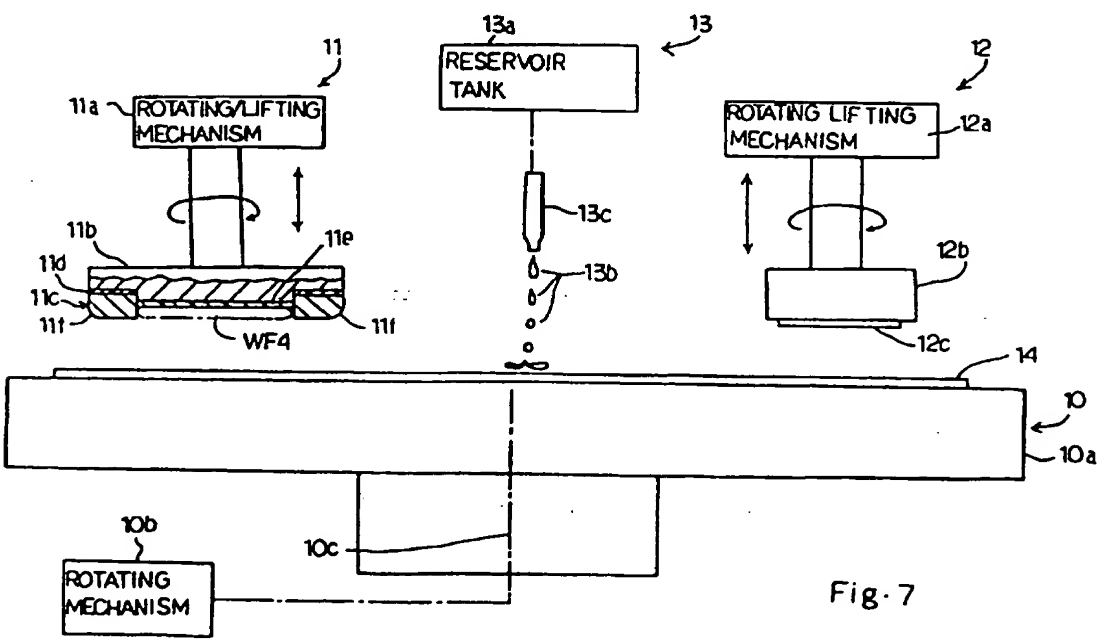
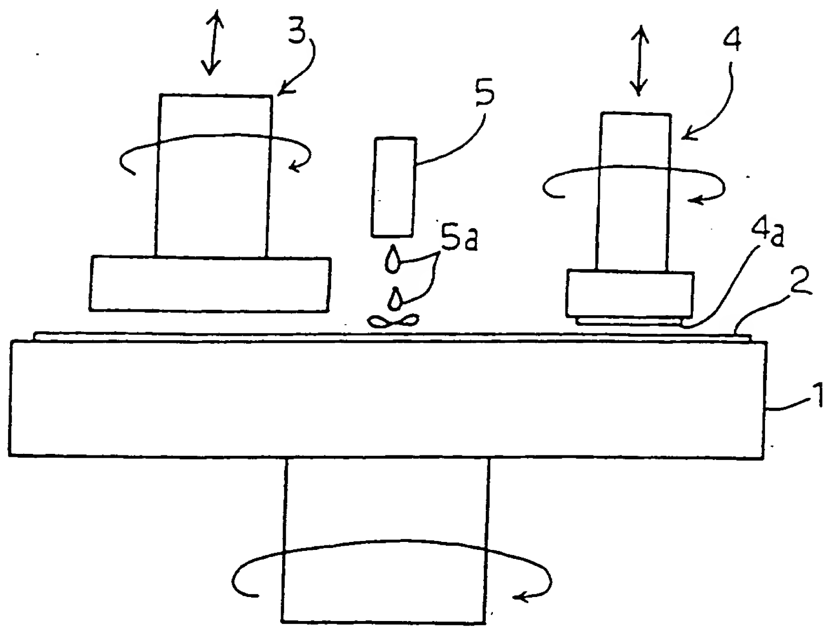


Fig. 7

GB 2 307 342 A



Fig·1
PRIOR ART

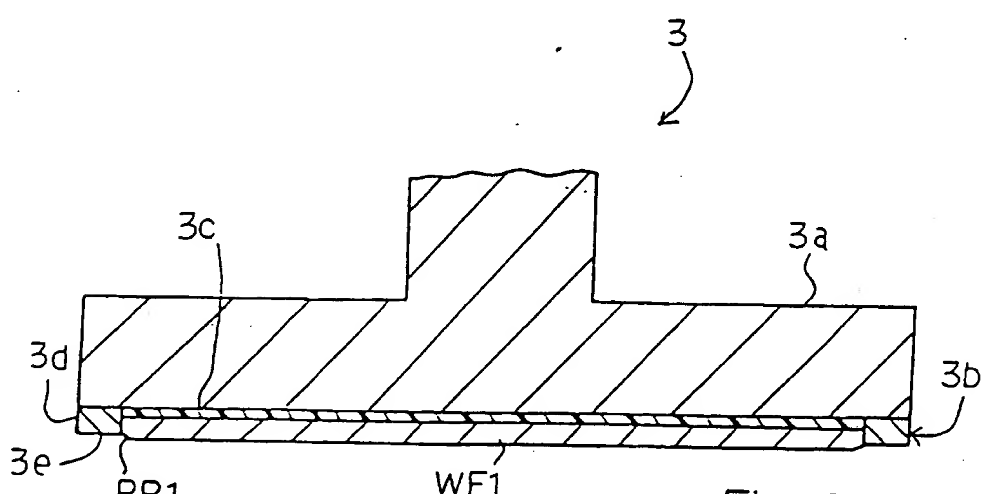


Fig:2
PRIOR ART

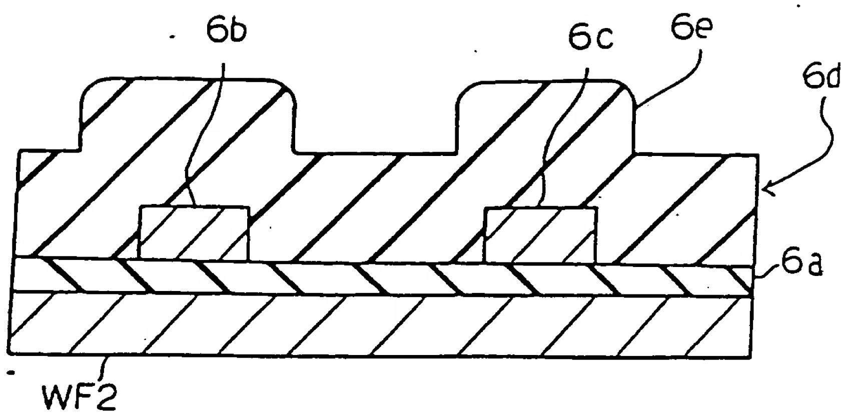


Fig. 3A
PRIOR ART

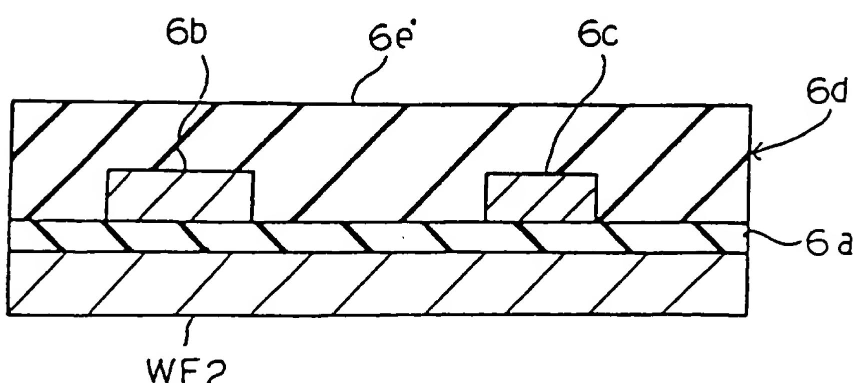


Fig. 3B
PRIOR ART

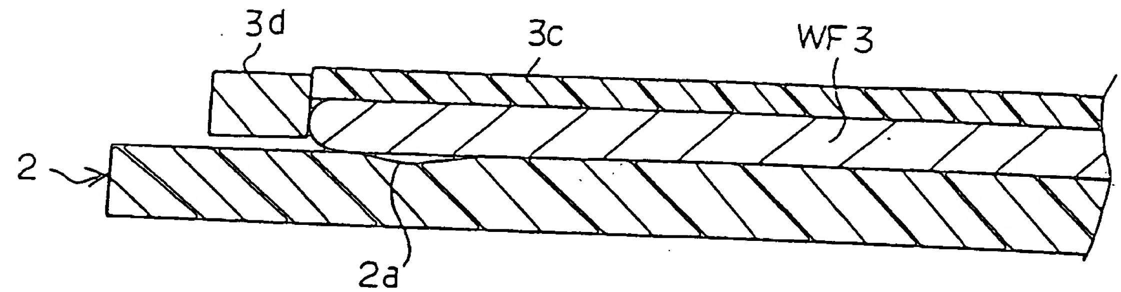


Fig.4
PRIOR ART

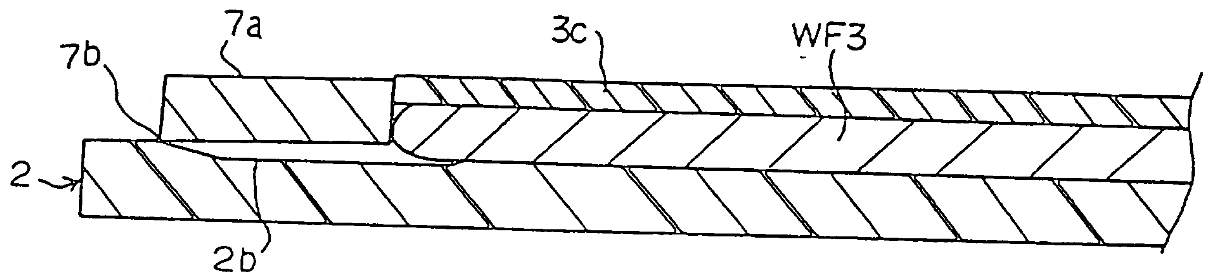


Fig.5
PRIOR ART

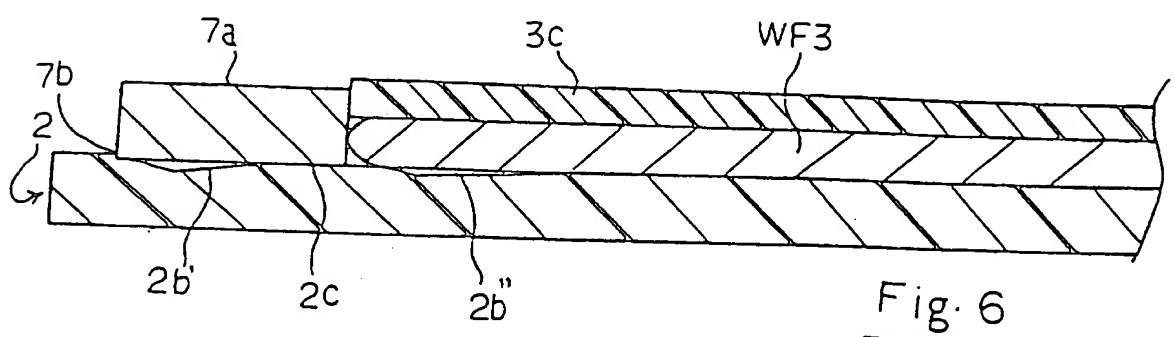


Fig. 6
PRIOR ART

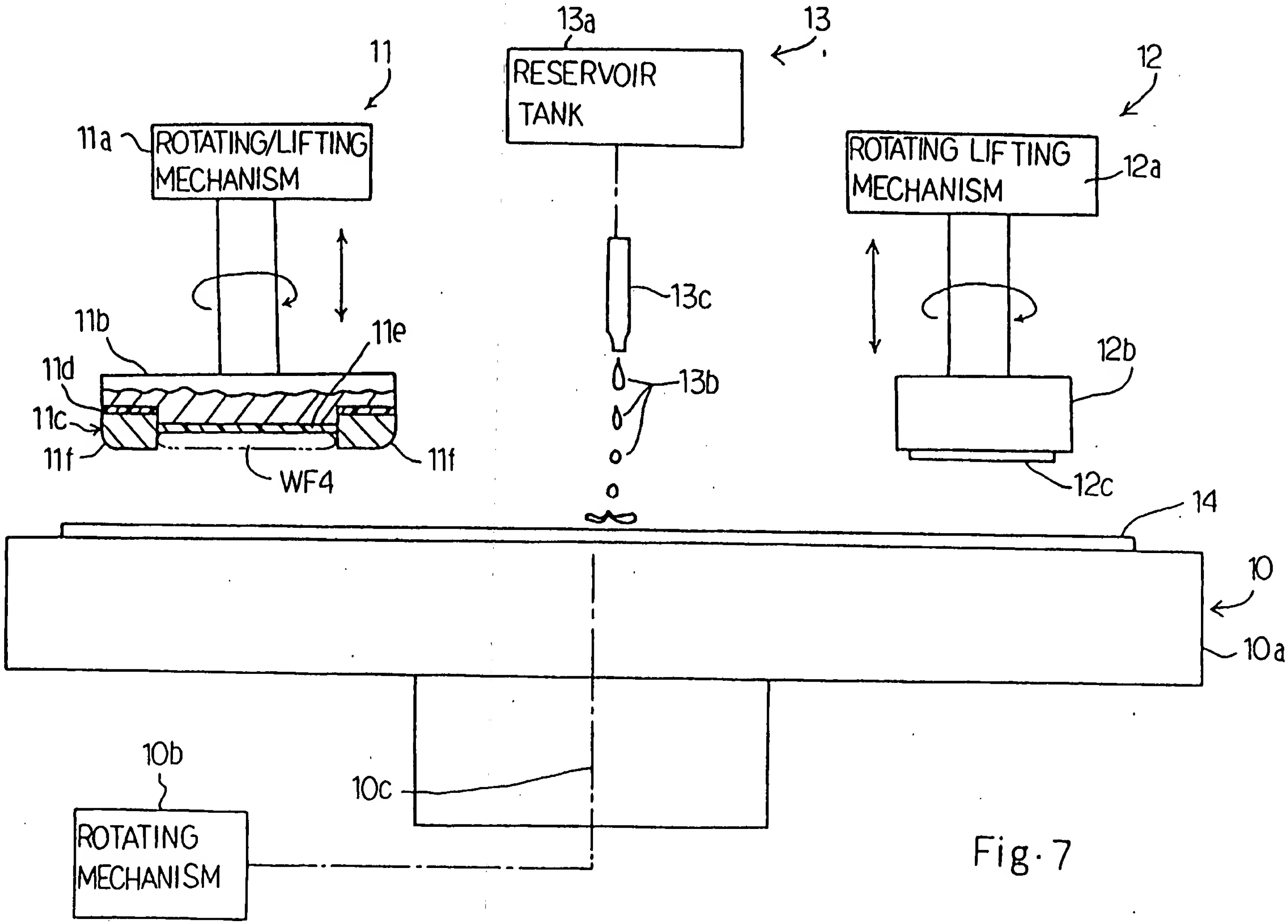

11
11a
ROTATING/LIFTING MECHANISM
11b
11d
11c
11f
11e
WF4
11f
13a
13
RESERVOIR TANK
13c
13b
12
ROTATING LIFTING MECHANISM
12a
12b
12c
14
10
10a
10b
ROTATING MECHANISM
10c

Fig. 7

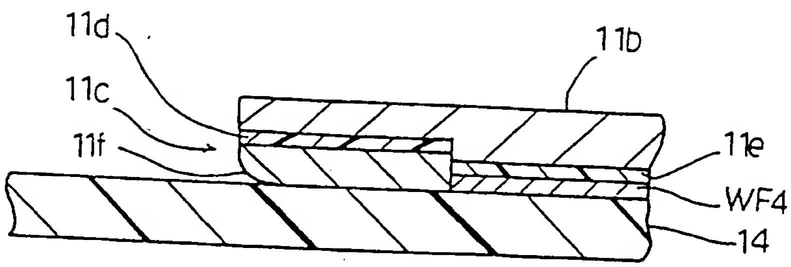
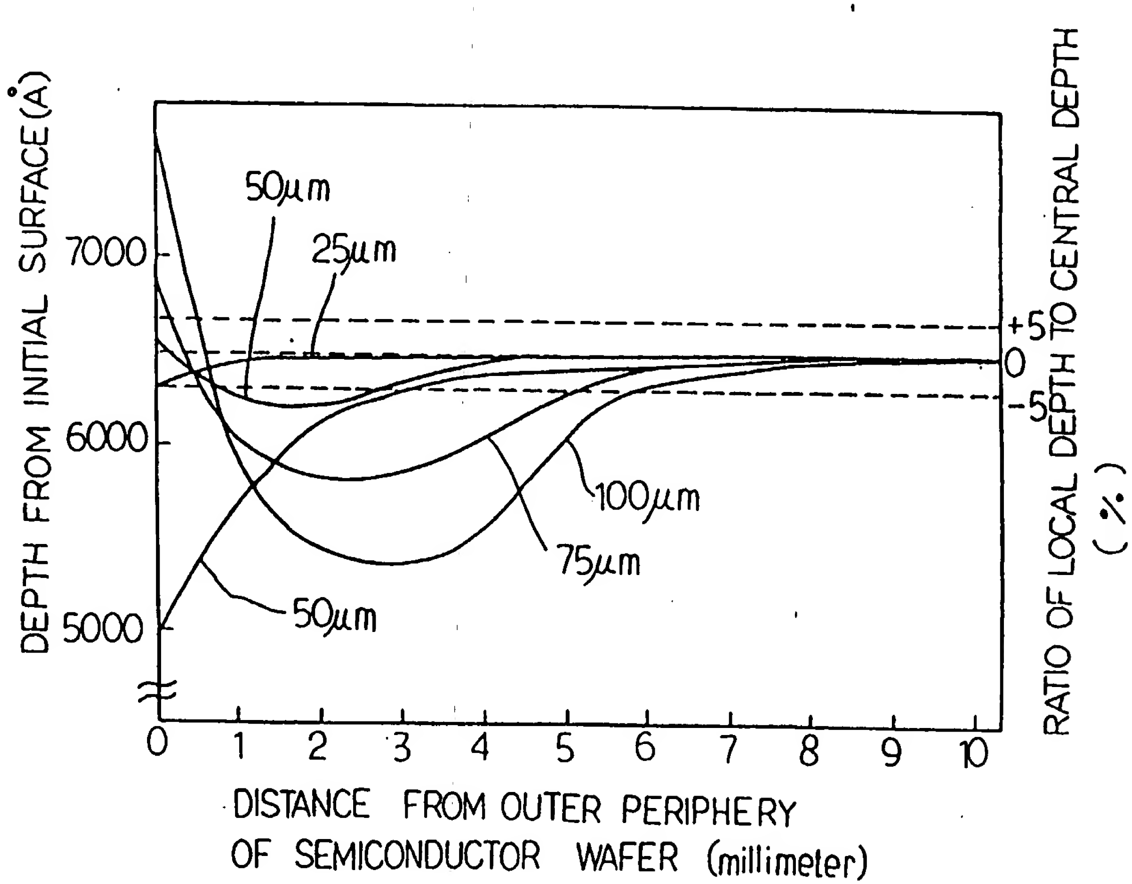


Fig. 8



DEPTH FROM INITIAL SURFACE (Å)
7000
6000
5000
50μm
25μm
100μm
75μm
50μm
+5
0
-5
RATIO OF LOCAL DEPTH TO CENTRAL DEPTH (%)
0
1
2
3
4
5
6
7
8
9
10
DISTANCE FROM OUTER PERIPHERY OF SEMICONDUCTOR WAFER (millimeter)

Fig.9

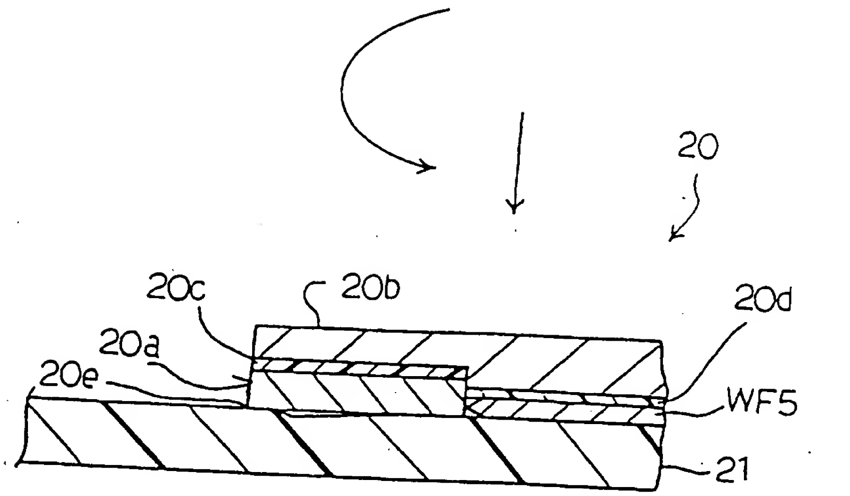


Fig. 10

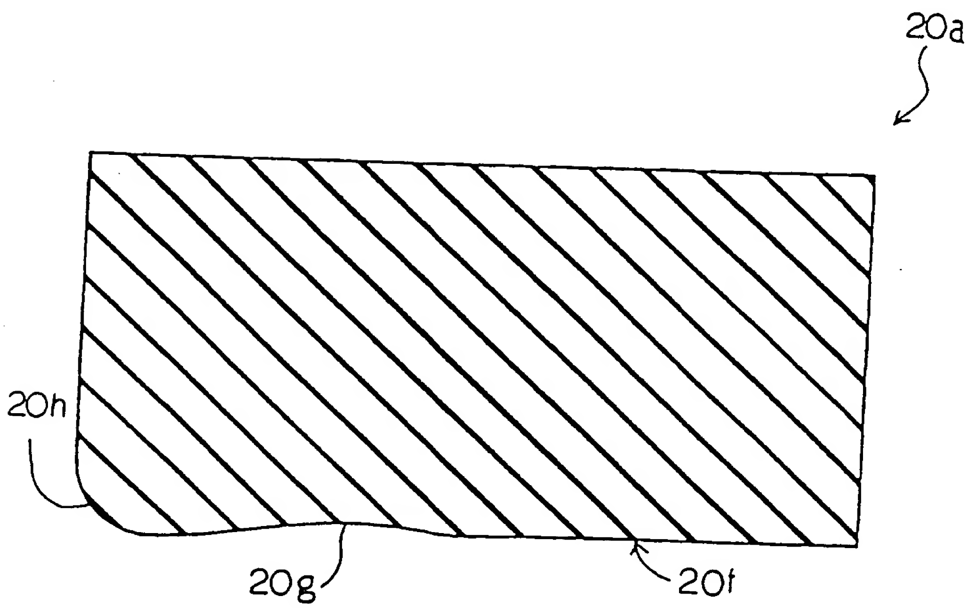


Fig. 11

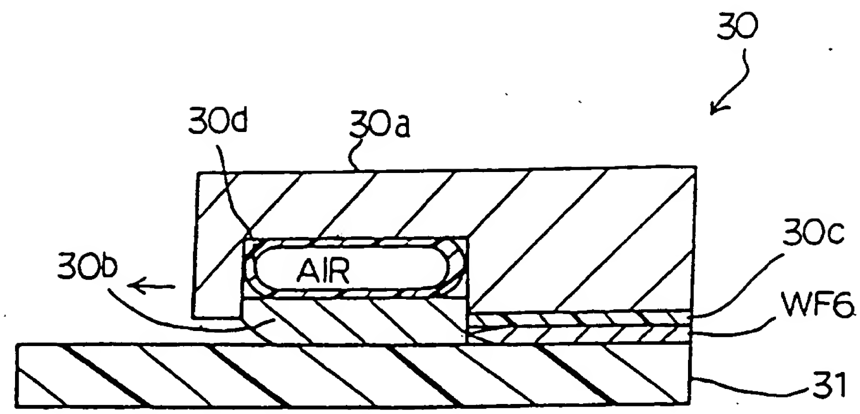


Fig. 12

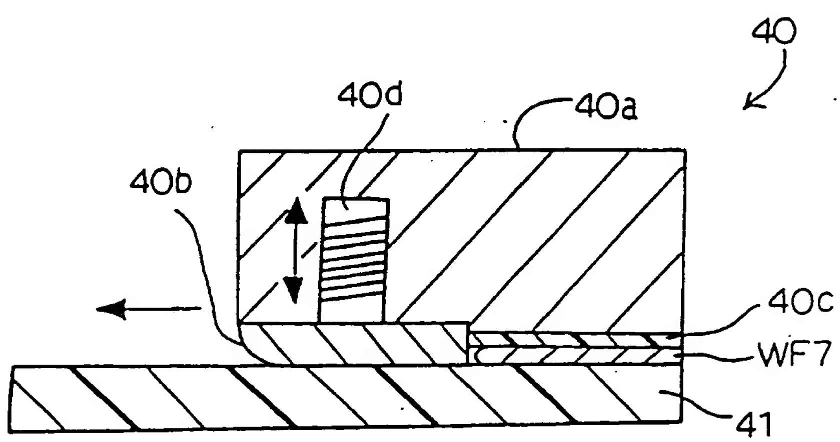


Fig. 13

2307342

POLISHING APPARATUS

This invention relates to a polishing apparatus for creating a flat surface on a semiconductor wafer and, more particularly, to a polishing apparatus having retainer ring rounded along the outer periphery of the lower surface and a method of regulating the retainer ring to an appropriate configuration.

A lithography process requires a high degree of global planarity on a semiconductor wafer, and a semiconductor device manufacturer repeats a polishing in the manufacturing process for a semiconductor integrated circuit device. For example, a lower conductive pattern for word lines is covered with an inter-level insulating layer, and the rise and fall due to the conductive pattern is transferred to the upper surface of the inter-level insulating layer. In order to form contact holes in the inter-level insulating layer, a photo-resist layer is spread over the inter-level insulating layer, and the rise and fall of the inter-level insulating layer affects the

global planarity of the upper layer of the photo-resist layer. A pattern image for the contact holes is optically transferred from a photo-mask to the upper surface of the photo-resist layer so as to form a latent image. However, if the global planarity of the upper layer is poor, the pattern image is locally defocused on the upper surface of the photo-resist layer, and does not exactly form the latent image in the photo-resist layer.

If the inter-level insulating layer is polished before the optical pattern transfer, the pattern image is exactly focused on the entire upper surface of the photo-resist layer, and, accordingly, forms the latent image exactly corresponding thereto. The minimum pattern geometry is getting severer and severer, and the optical pattern transfer requires a higher degree global planarity. Thus, the polishing is indispensable step of a process of fabricating an ultra large scale integration.

An inter-level insulating layer is polished by using a chemical mechanical polishing apparatus, and the polishing pad is usually different between the polishing for the inter-level insulating layer and the polishing for creating a smooth surface on a semiconductor wafer. When a semiconductor wafer is polished, the semiconductor wafer is

pressed against a polishing pad formed from non-woven fabric. On the other hand, it is desirable for an inter-level insulating layer to use a polishing pad formed of material harder than the non-woven fabric such as urethane foam. The polishing pad is usually formed from a soft cushion layer and a hard polishing layer. The hard polishing layer is laminated on the soft cushion layer, and the soft cushion layer is expected to make the hard polishing layer uniformly held in contact with a surface to be polished.

Figure 1 illustrates a typical example of the polishing apparatus. The prior art polishing apparatus comprises a rotatable polishing table 1, and a polishing pad 2 attached to the upper surface of the rotatable polishing table 1. The polishing pad 2 is formed of a soft cushion layer and a hard polishing layer. Though not shown in figure 1, the rotatable polishing table 1 is accompanied with a suitable driving mechanism, and is driven for rotation around a center axis thereof.

The prior art polishing apparatus further comprises a wafer holder 3, a conditioner 4 and a slurry feeder 5. The wafer holder 3 is swingable, rotatable and movable in an up-and-down direction. The wafer holder 3 presses a semiconductor wafer against the polishing pad 2, and gives

rise to a relative motion between the semiconductor wafer and the polishing pad 2.

The conditioner 4 is also swingable, rotatable and movable in the up-and-down direction. The conditioner 4 presses a diamond-coated pellet 4a against the polishing pad 2, and gives rise to a relative motion between the diamond-coated pellet 4a and the polishing pad 2 so as to keep the polishing pad 2 clear.

The slurry feeder 5 is provided over the polishing pad 2, and mixture 5a of polishing slurry and water is dripped from the slurry feeder 5 onto the polishing pad 2 during the polishing. The polishing slurry participates both chemical and mechanical steps in the polishing.

Turning to figure 2, the wafer holder 3 includes a hub 3a and a retainer ring 3b detachable from the hub 3a. A resilient pad layer 3c, which is called an "insert pad", is provided between the lower surface of the hub 3a and a semiconductor wafer WF1 , and the retainer ring 3b prevents the semiconductor wafer WF1 from a side slip on the polishing pad 2. The retainer ring 3b is formed of hard synthetic resin, and has a side surface 3d at right angles with respect to a lower surface 3e. The semiconductor wafer WF1 has a rounded outer periphery PR1, and projects

from the lower surface 3e of the retainer ring 3b by about 200 microns.

Using the prior art polishing apparatus, a flat surface is created on an inter-level insulating layer as follows. Figure 3A illustrates a semiconductor structure fabricated on a semiconductor wafer WF2. A field oxide layer 6a is selectively grown on the major surface of the semiconductor wafer WF2, and lower metal wirings 6b/6c are formed on the field oxide layer 6a. The lower metal wirings 6b/6c are 0.8 micron thick. An inter-level insulating layer 6d of silicon oxide is deposited to 2 microns thick over the field oxide layer 6a and the lower wirings 6b/6c by using a plasma-assisted chemical vapor deposition. The lower metal wirings 6b/6c and the exposed surface of the field oxide layer 6a form a rise and fall surface, and the rise and fall is transferred to an upper surface 6e of the inter-level insulating layer 6d.

The semiconductor wafer WF2 is held by the wafer holder 3, and is pressed against the polishing pad 2 at 500 g/cm^2. The polishing pad 2 is, by way of example, a lamination of IC1000 and SUBA400 manufactured by Rodel Corporation, and SC112 manufactured by Cabot Corporation is supplied from the slurry feeder 5 to the polishing pad at 100 cc/minute. The polishing table 1 is rotated at 20

rpm, and the wafer holder 3 rotates the semiconductor wafer WF2 at 20 rpm on the polishing pad 2. Then, the inter-level insulating layer 6d of silicon oxide is polished at 1300 angstroms per minute. Though not shown in figures 3A and 3B, a pattern of 3mm x 3 mm is formed over the semiconductor wafer WF2, and is also covered with the inter-level insulating layer 6d. A step takes place in the inter-level insulating layer 6d, and is referred to as "global step". The polishing is continued for 5 minutes, and a flat upper surface 6e' is created on the inter-level insulating layer 6d as shown in figure 3B. The global step is decreased to 1000 angstroms.

However, a polishing rate is not constant over the polished surface of the semiconductor wafer WF2. This phenomenon is derived from the two-layer polishing pad 2. When the wafer holder 3 presses a semiconductor wafer WF3 against the polishing pad 2 as shown in figure 4, the contact pressure is maximized in the outer peripheral area of the semiconductor wafer WF3, and the polishing pad 2 is deformed in an inner area 2a inside of the outer peripheral area due to the reaction. The inner area 2a ranges from several millimeters to several centimeters depending upon the polishing conditions and the elastic modulus of the

insert pad 3c. As a result, the semiconductor wafer WF3 is softly pressed against the inner area 2a, and the semiconductor wafer WF3 is partially less polished by the polishing pad 2.

If the deformation of the polishing pad 2 takes place outside of a semiconductor wafer, the deformation would not affect the polishing rate. From this aspect, the retainer ring 3d is replaced with a retainer ring 7a which is regulated in such a manner as to be held in contact with the polishing pad 2 together with the semiconductor wafer WF3. When the retainer ring 7a and the semiconductor wafer WF3 are pressed against the polishing pad 2, the contact pressure is maximized at the outer periphery of the retainer ring 7a, and the polishing pad 2 is deformed inside the outer periphery of the retainer ring 7a as shown in figure 5. However, the retainer ring 7a is designed to be wider than the inner area 2a, and the deformed area 2b is expected not to reach the outer periphery of the semiconductor wafer WF3.

However, the retainer ring 7a widely deforms the polishing pad 2, and the deformed area 2b reaches the outer peripheral area of the semiconductor wafer WF3 as shown in figure 5. Otherwise, the retainer ring 7a deforms the polishing pad 2 twice as shown in figure 6. Even if a non-

deformed area 2c takes place between the outer deformed area 2b' and the inner deformed area 2b", the inner deformed area 2b" reduces the contact pressure between an inner area of the semiconductor wafer WF3 and the polishing pad 2.

The reason why the polishing pad 2 is widely deformed is that the sharp outer peripheral edge 7b of the retainer ring 7a exerts larger pressure on the polishing pad 2. If the retainer ring 7a is wider than the deformed area 2b and the total width of the outer deformed area 2b', the non-deformed area 2c and the inner deformed area 2b", the deformation would not affect the polishing rate. However, such an extremely wide retainer ring 7a impedes the mixture 5a toward the contact area between the semiconductor wafer WF3 and the polishing pad 2, and decreases the polishing rate.

Another problem is analogous to a dressing effect concurrently carried out together with a polishing. It has been known to a person skilled in the art that the dressing concurrently carried out together with the polishing makes the polishing rate stable; however, the dressing effect deteriorates the flatness as reported by Hayakawa and Muroyama in the proceedings of 42 Spring Meetings of

Japanese Applied Physics, page 788, 30p-C-16. When the retainer ring 7a is held in contact with the polishing pad 2, the flatness is deteriorated. Moreover, while the retainer ring 7a is being rubbed with the polishing pad 2, undesirable contaminant is spread over the polishing pad 2, and is taken into the semiconductor wafer WF3. The contaminant thus taken into the semiconductor wafer WF3 deteriorates the device characteristics of integrated circuit devices fabricated on the semiconductor wafer WF3.

These are deteriorated with age, and, accordingly, affect the reproducibility. Another factor of the poor reproducibility relates to the insert pad 3c. The insert pad 3c is resiliently compressive, and allows the semiconductor wafer WF3 to sink depending upon the reaction of the load exerted on the semiconductor wafer WF3. Moreover, the insert pad 3c tends to lose the resiliency with time. For this reason, even if the wafer holder 3 exerts constant load on the semiconductor wafer WF3, the projecting length of the semiconductor wafer WF3 is changed, and, accordingly, varies the influence of the dressing effect and the feeding rate of the mixture 5a to the gap between the semiconductor wafer WF3 and the polishing pad 2.

Thus, the prior art polishing apparatus suffers from

undesirable variation in the polishing rate and unstable uniformity on the polished surface.

It is therefore an object of at least the preferred embodiments of the present invention to provide a polishing apparatus which uniformly finishes a surface at a constant polishing rate without contamination from a retainer ring.

It is also another such object of the present invention to provide a method of regulating a retainer ring to an appropriate configuration for the polishing apparatus.

To accomplish the above objects, the present invention proposes to decrease the maximum contact pressure between a retainer ring and a polishing pad.

According to a first aspect of the present invention, there is provided a wafer holder for use during the abrasive removal of material from a surface of the wafer, the holder comprising retaining means defining a housing for a wafer, said retaining means having an upper surface, a lower surface opposite to said upper surface, a side surface extending from upper surface towards said lower surface and a round surface extending between said side surface and said lower surface.

Preferably, the holder further comprises a hub member, the upper surface of said retaining means being attached to a lower surface of said hub member, and resilient regulating means inserted between said hub member and said retaining means and said hub member and said housing for regulating a height difference between said lower surface of said retaining means and the surface of a wafer from which material is to be abrasively removed housed in said housing.

The retaining means may comprise a retaining ring, the lower surface of which may be formed from the same material as the wafer from which material is to be abrasively removed.

A preferred embodiment of the present invention provides apparatus for polishing a wafer, the apparatus including a holder as described above. The apparatus may further comprise a polishing pad and drive means for generating a relative motion between said wafer and said polishing pad.

A second aspect of the present invention provides a polishing apparatus for polishing a wafer comprising:

a polishing pad;

a wafer holder provided over said polishing pad, and including a hub member and a retainer ring attached to a lower surface of said hub member so as to define an inner space between said hub member and said polishing pad wherein said wafer is to be accommodated; and

a driving means for generating a relative motion between said wafer and said polishing pad;

said retainer ring having an upper surface attached to said lower surface of said hub member, a lower surface adapted to be pressed against said polishing pad together with said wafer, a side surface merged with said upper surface and a round surface merged with said side surface and said lower surface.

A third aspect of the present invention provides apparatus for abrasively removing material from a surface of a wafer, said apparatus comprising:

abrasive means for abrading said surface, said abrasive means having a substantially planar surface; and

a wafer holder comprising retaining means defining a housing for a wafer, said retaining means having a lower surface adapted to contact said planar surface of said abrasive means during the abrading of the surface of the wafer, said lower surface being formed from the same material as the wafer

Preferably, the holder further comprises a hub member, and wherein said retaining means has a upper surface attached to a lower surface of said hub member, a side surface extending from said upper surface towards said lower surface and a round surface extending between said side surface and said lower surface.

The holder may further comprise resilient regulating means inserted between said hub member and said retaining means and said hub member and said housing for regulating a height difference between said lower surface of said retaining means and the surface of a wafer housed in said housing from which material is to be abrasively removed.

The above apparatus preferably comprises polishing apparatus for polishing a wafer, said abrasive means comprising a polishing pad, said apparatus further comprising drive means for generating a relative motion between said lower surface of said retaining means and said polishing pad.

A fourth aspect of the present invention provides a polishing apparatus for polishing a wafer comprising:

a polishing pad;

a wafer holder provided over said polishing pad, and including a hub member and a retainer ring attached to a lower surface of said hub member so as to define an inner space between said hub member and said polishing pad where said wafer is to be accommodated;

said retainer ring having a contact surface portion formed from the same material as a surface portion of said wafer to be polished and adapted to be held in contact with said polishing pad together with said surface portion of said wafer; and

a driving means for generating a relative motion between said contact surface portion, said surface portion of said wafer and said polishing pad.

A fifth aspect of the present invention provides a method of regulating a retainer ring to an appropriate configuration, comprising the steps of:

a) attaching a retainer ring having a contact surface portion formed from quartz to a rotatable hub member;

b) retaining a dummy wafer within said retainer ring on a polishing pad;

c) polishing said dummy wafer and said retainer ring through a relative motion of said wafer and said retainer ring to said polishing pad so as to transfer a deformation of said polishing pad to said contact surface portion of said retainer ring; and

d) determining a configuration of a contact surface portion of a retainer ring in such a manner as to prevent transfer of said deformation to said wafer.

Preferred features of the present invention will now be described, purely by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a schematic view showing the prior art polishing apparatus;

Fig. 2 is a cross sectional view showing the semiconductor wafer held by the wafer holder of the prior art polishing apparatus;

Figs. 3A and 3B are cross sectional views showing the polishing sequence carried out by using the prior art polishing apparatus;

Fig. 4 is a cross sectional view showing the deformation of the polishing pad due to the pressure of the

semiconductor wafer;

Fig. 5 is a cross sectional view showing the deformation of the polishing pad due to the pressure of the wide retainer ring;

Fig. 6 is a cross sectional view showing another kind of deformation of the polishing pad due to the pressure of the wide retainer ring;

Fig. 7 is partially cut-away schematic view showing a polishing apparatus according to the present invention;

Fig. 8 is a cross sectional view showing a retainer ring and a semiconductor wafer pressed against a polishing pad;

Fig. 9 is a graph showing the surface profile of polished semiconductor wafers;

Fig. 10 is a cross sectional view showing a wafer holder incorporated in another polishing apparatus according to the present invention;

Fig. 11 is a cross sectional view showing the configuration of a quartz retainer ring subjected to a polishing;

Fig. 12 is a cross sectional view showing a wafer holder incorporated in yet another polishing apparatus according to the present invention; and

Fig. 13 is a cross sectional view showing a wafer

holder incorporated in still another polishing apparatus according to the present invention.

Referring to figure 7 of the drawings, a polishing apparatus embodying the present invention largely comprises a turn table structure 10, a wafer holder 11, a cleaner 12, a slurry feeder 13 and a polishing pad 14. Though not shown in figure 7, the turn table 10 is rotatably supported by a frame structure, and the frame structure maintains the wafer holder 11, the cleaner 12 and the slurry feeder 13 over the turn table 10.

The turn table 10 includes a disk-shaped table 10a rotatable with respect to the frame structure (not shown) and a driving mechanism 10b connected to the disk-shaped table 10a. When the driving mechanism 10b is energized, the driving mechanism 10b rotates the disk-shaped table 10a around the center axis 1-c thereof. The polishing pad 14 is placed on the upper surface of the disk-shaped table 10a, and is a two-layer lamination. A soft cushion layer and a hard polishing layer form in combination the polishing pad 14 as similar to that of the prior art polishing pad 2.

The wafer holder 11 includes a rotating/lifting mechanism 11a, a hub member 11b connected to the rotating/lifting mechanism 11a, a retainer ring detachable from the hub member 11b, a cushion member 11d inserted between the hub member 11b and the retainer ring 11c and an insert pad 11e.

The retainer ring 11c is formed of hard synthetic resin, and prevents a semiconductor wafer WF4 from a side slip on the polishing pad 14 during a polishing. The semiconductor wafer WF4 may be covered with a silicon oxide layer to be polished. The outer periphery 11f of the retainer ring 11c is rounded, and the radius of curvature of the outer periphery 11f is 1 millimeter in this instance. The insert pad 11e has resiliency, and is sandwiched between the lower surface of the hub member 11b and the semiconductor wafer WF4. The cushion member 11d also has resiliency, and is inserted between the lower surface of the hub member 11b and the retainer ring 11c. In this instance, the cushion member 11d is formed of certain resilient material same as the insert pad 11e. The insert pad 11e and the cushion member 11d regulate the semiconductor wafer WF4 and the retainer ring 11c in such a manner as to be coplanar with each other on the polishing pad 14 as shown in figure 8. The cushion member 11d and

the insert pad 11e as a whole constitute a regulating means.

The rotating/lifting mechanism 11a presses the retainer ring 11f and the semiconductor wafer WF4 against the polishing pad 14, and rotates them thereon so as to polish the semiconductor wafer WF4. When the retainer ring 11c is pressed against the polishing pad 14 together with the semiconductor wafer WF4, the retainer ring 11c is held in contact with the polishing pad 14 over 10 millimeter in width. The rotating mechanism 10b and the rotating/lifting mechanism 11a as a whole constitute a driving means for generating a relative motion between the semiconductor wafer WF4 and the polishing pad 14.

The conditioner 12 includes a rotating/lifting mechanism 12a, a hub member 12b connected to the rotating/lifting mechanism 12a and a diamond-coated pellet 12c retained by the hub member 12b. The rotating/lifting mechanism 12a gives rise to a relative motion between the polishing pad 14 and the diamond-coated pellet 12c between the polishing works, and keeps the polishing pad 14 clean.

The diamond-coated pellet 12c may be used for the polishing pad 14 during the polishing.

The slurry feeder 13 includes a reservoir tank 13a filled with mixture 13b of polishing slurry and water and a

nozzle 13c connected to the reservoir tank 13a. While the polishing pad 14 is polishing the semiconductor wafer 14, the mixture 13b is dripped onto the polishing pad 14 for a chemical and mechanical polishing.

The polishing is carried out as follows. First, the semiconductor wafer WF4 is regulated in such a manner as to be substantially coplanar with the lower surface of the retainer ring 11c. The rotating/lifting mechanism 11a presses the semiconductor wafer WF4 and the retainer ring 11c against the polishing pad 14, and the rotating mechanism 10b and the rotating/lifting mechanism 11a give rise to a relative motion between the polishing pad 14 and the semiconductor wafer/retainer ring WF4/11c.

The cushion member 11d and the insert pad 11e keep the semiconductor wafer WF4 and the retainer ring 11c substantially coplanar with each other on the polishing pad 14, i.e., the projection length of the semiconductor wafer WF4 from the lower surface of the retainer ring 11c is approximately equal to zero during the polishing. Even through the polishing conditions are changed, the cushion member 11d and the insert pad 11e keep the relation between the semiconductor wafer WF4 and the retainer ring 11c, i.e., the semiconductor wafer WF4 and the retainer ring 11c substantially coplanar with each other on the polishing pad

14. Although long running hours deteriorate the cushion member 11d and the insert pad 11e in resiliency, the aged deterioration evenly affects the cushion member 11d and the insert pad 11e, and the cushion member 11d and the insert pad 11e still keep the semiconductor wafer WF4 and the retainer ring 11c coplanar with each other on the polishing pad 14.

The round outer periphery 11f decreases the dressing effect to the polishing pad 14, and effectively achieves good surface flatness. Moreover, the round outer periphery 11f allows the mixture 13b to flow through the retainer ring 11c into the semiconductor wafer WF4, and the mixture 13b makes the polishing stable.

The present inventors measured the surface profile of semiconductor wafers, and plotted in figure 9. The projection length of the semiconductor wafers from the retainer ring was changed from -50 microns through 25 microns, 50 microns, 75 microns to 100 microns. When the projection length was regulated within ± 50 microns, the ratio of local depth to central depth at or inside of 3 millimeters from the outer periphery of the semiconductor wafers fell within ± 5 percent. The "local depth" and the "central depth" respectively mean the depth at an arbitrary

point from the initial surface and the depth in a central area from the initial surface.

The present inventors further evaluated influences of the round outer periphery 11f and the contact width between the retainer ring 11c and the polishing pad 14. The present inventors prepared various retainer rings 11c different in radius of curvature R of the round outer periphery 11f and the width W of the flat lower surface, i.e., the contact width between the retainer ring 11c and the polishing pad 14.

Using the retainer rings 11c, the present inventors polished the semiconductor wafers WF4, and, thereafter, measured the ratio of local depth to central depth DP, the polishing rate PL in the central area, the uniformity UF in the central area and the global step GS as shown in table 1.

The global step GS is described hereinbefore in connection with figures 3A and 3B, and is a step produced in an inter-level insulating layer over a metal wiring of 0.8 micron thick between a portion over a patter of 3 mm x 3 mm and a portion without a pattern. NW stands for a width of a non-effective area on the semiconductor wafers WF4, and the non-effective area is less in ratio of local depth to central depth than -5 percent and greater than +5

percent. PR represents the projection length of the semiconductor wafer WF4 from the retainer 11c.

Table 1

R (mm)	W (mm)	NW (mm)	PL (angstrom/min)	UF (%)	GS (angstrom)	PR (micron)
0	10	6	1300	5	1000	200
0	2	8	1300	5	1500	0
	4	8	1300	5	1500	ditto
	6	7	1300	5	1500	ditto
	8	6	1300	5	1500	ditto
	10	5	1250	7	1500	ditto
	15	4	1150	9	1500	ditto
	20	3	1000	12	1500	ditto
0.75	2	6	1300	5	1300	ditto
	4	6	1300	5	1300	ditto
	6	5	1300	5	1300	ditto
	8	5	1300	5	1300	ditto
	10	4	1300	5	1300	ditto
	15	3	1200	7	1300	ditto
	20	2	1100	10	1300	ditto
1.0	2	5	1300	5	1150	ditto
	4	5	1300	5	1150	ditto
	6	4	1300	5	1150	ditto
	8	4	1300	5	1150	ditto
	10	3	1300	5	1150	ditto
	15	2	1250	6	1150	ditto

Table 1

1.0	20	1	1200	7	1150	ditto
	2	5	1300	5	1150	ditto
1.25	4	5	1300	5	1150	ditto
	6	4	1300	5	1150	ditto
	8	3	1300	5	1150	ditto
	10	2	1300	5	1150	ditto
	15	1	1250	6	1150	ditto
	20	1	1200	7	1150	ditto
1.5	2	5	1300	5	1150	ditto
	4	5	1300	5	1150	ditto
	6	4	1300	5	1150	ditto
	8	3	1300	5	1150	ditto
	10	2	1300	5	1150	ditto
	15	1	1250	6	1150	ditto
	20	1	1200	7	1150	ditto

As will be understood from the foregoing description, the width of the non-effective area NW and the polishing rate PL were inversely proportional to the width of retainer ring W, and the uniformity UF was deteriorated together with the polishing rate PL due to a large impedance of the retainer ring 11c against the flow of mixture 13b. A large radius of curvature R was desirable, because the large

radius of curvature R prevented the semiconductor wafers WF4 from a wide non-effective area NW in spite of a narrow width W of the retainer ring 11c. Especially, when the radius of curvature R was equal to or greater than 1 millimeter, the retainer ring 11c was effective against non-acceptable surface profile of the semiconductor wafer. The retainer ring 11c slightly degraded the global step GS.

As will be appreciated from the foregoing description, the polishing apparatus according to the present invention is equipped with a retainer ring having a round outer periphery, and the round outer periphery is effective against a local slope on the polished surface of the semiconductor wafer WF4.

Turning to figure 10 of the drawings, another wafer holder 20 retains a semiconductor wafer WF5 covered with a silicon oxide layer to be polished on a polishing pad 21. The wafer holder 20 forms a part of a polishing apparatus embodying the present invention, and other component members and units are similar to those of the first embodiment. For this reason, description is focused on the wafer holder 20.

The wafer holder 20 includes a retainer ring 20a and

a hub member 20b having a central lower surface and an peripheral lower surface. The retainer ring 20a is attached to the hub member 20b, and a cushion member 20c is inserted between the lower peripheral surface and the retainer ring 20a. An insert pad 20d is provided between the lower central surface of the hub member 20b and the semiconductor wafer WF5, and the hub member 20b presses the retainer ring 20a and the semiconductor wafer WF5 against the polishing pad 21. The cushion member 20c and the insert pad 20d are formed of certain resilient material, and regulates the retainer ring 20a and the semiconductor wafer WF5 in such a manner as to be substantially coplanar with each other on the polishing pad 21. The cushion member 20c and the insert pad 20d thus formed of the same material is effective against aged deterioration, because the aged deterioration evenly degrades the resiliency of the cushion member 20c and the insert pad 20d. The cushion member 20c and the insert pad 20d as a whole constitute a regulating means.

If the difference between the lower surface of the retainer ring 20a and the polished surface of the semiconductor wafer WF5 is equal to or less than 50 microns, the polishing apparatus achieves a good surface flatness as similar to the first embodiment.

The retainer ring 20a is formed of quartz or has a lower surface portion of quartz, and the outer periphery 20e is equal in radius of curvature to or less than 0.1 millimeter. The retainer ring 20a is held in contact with the polishing pad 21 through the quartz, and is free from the dressing effect. Moreover, the surface portion of the semiconductor wafer WF5 to be polished is the same material as the retainer ring 20a, and, for this reason, the semiconductor wafer WF5 is free from contamination from the retainer ring 20a. The quartz may be deposited by using a chemical vapor deposition.

The present inventors evaluated the polishing apparatus implementing the second embodiment as similar to the first embodiment. The evaluation was summarized in table 2.

Table 2

R (mm)	W (mm)	NW (mm)	PL (angstrom/min)	UF (%)	GS (angstrom)
0	10	6	1300	5	1000

As will be understood, the non-effective area on the semiconductor wafer WF5 was narrow, and the present inventors confirmed that the quartz was effective against the local slope.

If the radius of curvature of the outer periphery 20e is enlarged to be at least 1 millimetre, the surface profile, the polishing rate and the uniformity are drastically improved rather than the retainer ring 20a.

Subsequently, description is made on a method of regulating the quartz retainer ring 20a to an appropriate configuration. First, the retainer ring 20a is attached to the hub member 20b, and a dummy wafer is retained on the polishing pad 21 as similar to the semiconductor wafer WF5. The dummy wafer is polished through a relative motion between the polishing pad 21 and the dummy wafer for 100 minutes, and the retainer ring 20a is also polished on the polishing pad 21.

Upon expiry of the polishing time, the contact surface 20f of the retainer ring 20a is shaped along the deformed surface of the polishing pad 21.

However, the retainer ring 20a may be released from the hub member 20b upon expiry of the polishing time so as to observe the contact surface 20f. While the retainer ring 20a is being polished together with the dummy wafer, the deformed surface of the polishing pad 21 is transferred to the contact surface 20f; a local slope 20g takes place in the contact surface 20g, and the outer periphery 20h is rounded as shown in figure 11. Then, an analyst can

determined where the deformation takes place in the polishing pad 21 on the basis of the local slope 20g and how the deformation affects the outer periphery of the retainer ring 20a. If the retainer ring 20a is wide enough to prevent a semiconductor wafer from the deformation corresponding to the local slope 20g and the outer periphery 20h is previously rounded, the polishing apparatus achieves a good surface profile on the semiconductor wafer. Thus, the analyst regulates the retainer ring 20a to an appropriate configuration having the minimum width for preventing a semiconductor wafer from the deformation and previously rounded outer periphery 20h.

A quartz retainer ring was used for polishing a dummy wafer for 100 minutes, and the contact surface of the quartz retainer rings was automatically matched with the deformed surface of the polishing pad. Using the quartz retainer ring thus automatically matched with the deformed surface of the polishing pad, even though the contact width between the quartz retainer ring and the polishing pad was minimized, an abnormal profile did not take place in the semiconductor wafer after a polishing. The polishing data were summarized in Table 3.

Table 3

R (mm)	W (mm)	NW (mm)	PL (angstrom/min)	UF (%)	GS (angstrom)
1	10	2	1300	5	1000

As will be understood from table 3, the width of non-effective area NW is drastically decreased rather than the semiconductor wafer shown in table 2, and the method of regulating the retainer ring effectively improves the surface profile of the semiconductor wafer.

Turning to figure 12 of the drawings, a wafer holder incorporated in a polishing apparatus embodying the present invention includes a hub member 30a, a retainer ring 30b, a resilient insert pad 30c provided between the hub member 30a and a semiconductor wafer WF6 and an air bag 30d inserted between the hub member 30a and the retainer ring 30b. In this instance, the insert pad 30c and the air bag 30d form in combination a regulating means.

The wafer holder 30 forms a part of a polishing apparatus embodying the present invention, and the other component members and units are similar to those of the first embodiment. For this reason, no further description is made on the other component members and units.

The inside air pressure of the air bag 30d is

regulable, and the insert pad 30c and the air bag 30d regulates the retainer ring 30b and the semiconductor wafer WF6 to be coplanar with each other on a polishing pad 31. The difference between the lower surface of the retainer ring 30b and the lower surface of the semiconductor wafer WF6 is equal to or less than 50 microns on the polishing pad 31.

The polishing apparatus implementing the third embodiment achieves all the advantages of the first embodiment.

Turning to figure 13 of the drawings, a wafer holder 40 incorporated in a polishing apparatus embodying the present invention includes a hub member 40a, a retainer ring 40b, a resilient insert pad 40c provided between the hub member 40a and a semiconductor wafer WF7 and a regulator 40d inserted between the hub member 40a and the retainer ring 40b. In this instance, the insert pad 40c and the regulator 40d form in combination a regulating means.

The wafer holder 40 forms a part of a polishing apparatus embodying the present invention, and the other component members and units are similar to those of the

first embodiment. For this reason, no further description is made on the other component members and units.

The regulator 40d memorizes the aged deterioration of the insert pad 40c, and changes the force exerted on the retainer ring 40b in such a manner as to regulate the retainer ring 30b and the semiconductor wafer WF6 to be coplanar with each other on a polishing pad 41. The difference between the lower surface of the retainer ring 40b and the lower surface of the semiconductor wafer WF7 is equal to or less than 50 microns on the polishing pad 31.

The polishing apparatus implementing the fourth embodiment achieves all the advantages of the first embodiment.

Although particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the scope of the present invention.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The text of the abstract filed herewith is repeated here as part of the specification.

A polishing apparatus has a retainer for retaining a semiconductor wafer (WF4) on a polishing pad (14), and the outer periphery (11f) of the retainer ring (11c) is rounded so as to minimize a deformation produced in the polishing pad, thereby improving the surface profile of the semiconductor wafer.

CLAIMS

1. A wafer holder for use during the abrasive removal of material from a surface of a wafer, the holder comprising retaining means defining a housing for a wafer, said retaining means having an upper surface, a lower surface opposite to said upper surface, a side surface extending from upper surface towards said lower surface and a round surface extending between said side surface and said lower surface.

2. Apparatus for abrasively removing material from the surface of a wafer, said apparatus including a holder as claimed in Claim 1.

3. Apparatus according to Claim 2 comprising apparatus for polishing a wafer, said apparatus further comprising a polishing pad and drive means for generating a relative motion between said wafer and said polishing pad.

4. A polishing apparatus for polishing a wafer comprising:

a polishing pad

a wafer holder provided over said polishing pad, and including a hub member and a retainer ring attached to a lower surface of said hub member so as to define an inner space between said hub member and said polishing pad where said wafer is to be accommodated; and

a driving means for generating a relative motion between said wafer and said polishing pad ;

said retainer ring having an upper surface attached to said lower surface of said hub member, a lower surface adapted to be pressed against said polishing pad together with said wafer, a side surface merged with said upper surface and a round surface merged with said side surface and said lower surface.

5. The polishing apparatus as set forth in claim 4, further comprising a regulating means resiliently inserted between said hub member and said retainer ring and between said hub member and said wafer for regulating a height difference between said lower surface of said retainer ring and a polished surface of said wafer when placed on said polishing pad to 50 microns or less.

6. The polishing apparatus as set forth in Claim 4 or Claim 5, in which said round surface has a radius of curvature equal to or greater than 1 millimetre.

7. Apparatus for abrasively removing material from a surface of a wafer, said apparatus comprising:

abrasive means for abrading said surface, said abrasive means having a substantially planar surface; and

a wafer holder comprising retaining means defining a housing for a wafer, said retaining means having a lower surface adapted to contact said planar surface of said abrasive means during the abrading of the surface of the wafer, said lower surface being formed from the same material as the wafer.

8. Apparatus according to Claim 7, comprising polishing apparatus for polishing a wafer, said abrasive means comprising a polishing pad, said apparatus further comprising drive means for generating a relative motion between said lower surface of said retaining means and said polishing pad.

9. A polishing apparatus for polishing a wafer comprising:

a polishing pad;

a wafer holder provided over said polishing pad, and including a hub member . and a retainer ring attached to a lower surface of said hub member so as to define an inner space between said hub member and said polishing pad wherein said wafer is to be accommodated;

said retainer ring having a contact surface portion formed from the same material as a surface portion of said wafer to be polished and adapted to be held in contact with said polishing pad together with said surface portion of said wafer; and

a driving means for generating a relative motion between said contact surface portion, said surface portion of said wafer and said polishing pad.

10. The polishing apparatus as set forth in claim 7, in which said contact surface portion is formed from quartz, and

said surface portion of said wafer is formed from silicon oxide.

11. The polishing apparatus as set forth in Claim 9 or Claim 10, further comprising a regulating means resiliently inserted between said hub member and said retainer ring and between said hub member and said wafer.

12. The polishing apparatus as set forth in claim 11, in which said retainer ring has a surface adapted to be held in contact with said polishing pad, an upper surface held in contact with said regulating means, a side surface merged with said upper surface and a round surface merged with said side surface and said contact surface, and the round surface has a radius of curvature equal to or greater than 1 millimetre.

13. The polishing apparatus as set forth in Claim 11 or Claim 12, in which a height difference between a contact surface of said contact surface portion and a contact surface of said surface portion to be polished is equal to or less than 50 microns when said holder is placed on said polishing pad.

14. A method of regulating a retainer ring to an appropriate configuration, comprising the steps of:

a) attaching a retainer ring having a contact surface portion formed from quartz to a rotatable hub member;

b) retaining a dummy wafer within said retainer ring on a polishing pad;

c) polishing said dummy wafer and said retainer ring through a relative motion of said wafer and said retainer ring to said polishing pad so as to transfer a deformation of said polishing pad to said contact surface portion of said retainer ring; and

d) determining a configuration of a contact surface portion of a retainer ring in such a manner as to prevent transfer of said deformation to said wafer.

15. The method as set forth in claim 14 in which said contact surface portion has a rounded outer periphery having a radius of curvature approximately equal to a round outer periphery of said constant surface portion of said retainer ring.

16. Apparatus for abrasively removing material from the surface of a workpiece or polishing apparatus substantially as herein described with reference to and as shown in Figure 7 of the accompanying drawings.

17. A holder substantially as herein described with reference to and a shown in any of Figures 8, 10, 12 or 13 of the accompanying drawings.

The Patent Office

Application No:	GB 9623693.0	**Examiner:**	C.D.Stone
Claims searched:	1-6	**Date of search:**	5 February 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H1K(KLXC); B3D(DMN)

Int Cl (Ed.6): H01L

Other: ON LINE,W.P.I.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2292254 A	NEC	1,4
X	EP0589433 A1	EBARA (See Fig.5)	1,4
X	EP0517594 A1	C.E.A. (See Figs.11-13)	1,4

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		